FINAL SURVEY REPORT
Piney Point Discharge Plume Tracking

Contract No. 68-C-03-041
Work Assignment No. 0-07

Submitted to

U.S. ENVIRONMENTAL PROTECTION AGENCY
Oceans and Coastal Protection Division
Washington, DC

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1. Introduction

The abandoned Piney Point phosphate fertilizer facility, in Manatee County, Florida contains more than a billion gallons of acidic, nutrient laden wastewater. Each rain event increases the water level. Under normal operations these retention ponds do not pose an environmental threat. When the plant was in operation the water was constantly reused and the heat generated by the manufacturing process kept the ponds around 140ºF. This promoted evaporation and minimized the potential for flooding. When the plant was abandoned in 2001, the ponds cooled and the evaporative process was lost. As rainfall continued to fill the ponds the risk increased for catastrophic spill of hundreds of millions of gallons of untreated wastewater into Tampa Bay. A spill of this nature would pose an imminent health and safety threat to many area residents, including risking the lives of the workers on site and flooding Highway 41 - a major hurricane evacuation route for more than 300,000 people in South Florida. In addition, the ecological results of such a disaster could include destruction of Tampa Bay's seagrass beds, massive fish kills, and harmful algal blooms.

On April 9, 2003, the U.S. Environmental Protection Agency (EPA) issued an emergency permit to the Florida Department of Environmental Protection (FDEP) to transport and disperse the treated wastewater from the Piney Point facility in a designated area of the Gulf of Mexico. The permit was issued to prevent a catastrophic spill, should heavy rains cause the overtopping or failure of the dikes at the facility. The dumping occured at least 100 nautical miles from shore in waters at least 40 meters deep and was dispersed slowly over a large area. The boundaries of the approved dumping Zone are shown in Figure 1. This area was designated to avoid areas of critical marine habitats.

Prior to dumping, the wastewater is treated using a double lime precipitation, aeration, and sedimentation process designed to neutralize acidity and precipitate fluoride, phosphorus, metals, and radionuclides. The treated wastewater is freshwater with a density of approximately 10005 kg/m^3, a pH of 6.5 to 8.0, and a suspended solids content of approximately 30 mg/L. Chemically, the treated wastewater's constituents should be within marine water quality criteria, with the exception of ammonia.

This survey was designed to measure pH levels and nutrient and particulate loading in the wake of the barge discharging the Piney Point treated wastewater. These concentrations are compared to background levels determined during pre-disposal measurements and sample collections. Data from this survey are then used to assess the overall nutrient and particulate loading to the Gulf of Mexico from the Piney Point discharge.

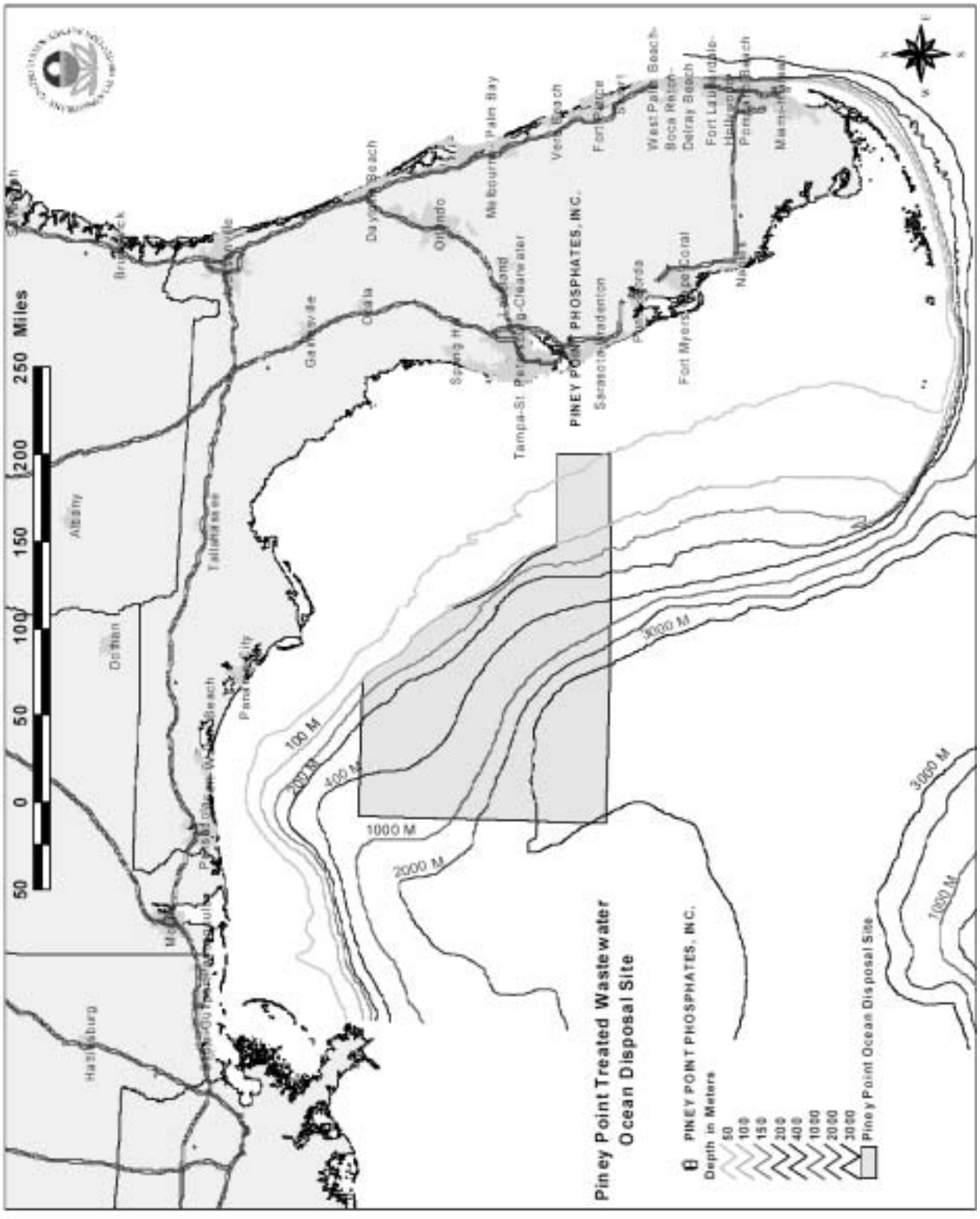

FIGURE 1. PINEY POINT TREATED WASTEWATER OCEAN DISPOSAL SITE

2. Methods

The following subsections briefly summarize the methods used during this survey. The combined work/quality assurance project plan (W/QAPP) for Ship Waste Stream Discharge Assessment (Battelle 2003a) contains additional details on survey sampling methods.

2.1. Method Descriptions

Survey Party

Battelle provided a three-person team during each portion of the survey. Survey personnel are listed in Table 1.

TABLE 1. SCIENTIFIC SURVEY PERSONNEL

Name	Responsibility
Kennard Potts	Chief Scientist (EPA)
Alex Mansfield	Second Scientist (Battelle)
Robert Mandeville	NavSam© Operator (Battelle)
Timothy Kaufman	Technician (Battelle)

Schedule

Two surveys were conducted under this work assignment. Each survey is described in detail below. Table 2 lists the survey dates and locations.

TABLE 2. SURVEY LOCATIONS

Survey	Dates	Docking Location	Survey Location
Pre-Discharge Survey	July 10-11, 2003	U.S. Coast Guard Station. St. Petersburg, FL	Transect Line Through Planned Discharge Area
Plume Tracking Survey	August 13-14, 2003	Port Manatee, FL	Cross Section of Waste Discharge Route

Navigation. Vessel positioning during sampling operations was accomplished using the vessel's differential Global Position System (dGPS) interfaced to Battelle's NavSam© navigation system. The dGPS receiver has six dedicated channels and is capable of locking onto twelve different satellites at one time. To correct the GPS calculations, the dGPS receives correction data from one of the United States Coast Guard dGPS broadcast sites in Florida: Key West, Virginia Key, Cape Canaveral, Macdill AFB, and Egmont Key. This capability ensured strong signal reception, and accurate and reliable positioning with 2-second updates.

Plume Tracking Using the Battelle Ocean Sampling System. Plume tracking was conducted using the Battelle Ocean Sampling System (BOSS) deployed from the EPA Ocean Survey Vessel Peter W. Anderson (OSV *Anderson*) (Figure 2). The BOSS was deployed approximately 10 ft. off of the port side of the *Anderson* using the boom crane to minimize the impact of the *Anderson*'s wake and propellers on the monitoring activities. The BOSS *in situ* sensor package included: a CTD (which measures temperature, conductivity, salinity (calculated), and pressure (for depth)), a transmissometer, and a pH sensor. Table 3 displays the array of sensors utilized.

A winch was used to control the depth of the towed sensor package. The BOSS sensor package was raised or lowered using the winch at a rate of 0 - 1.0 meters/second. Depending on the vessel's speed and winch operation, the system operated in three different modes: vertical profile, constant-depth towing, or towyo. In vertical profiling mode, data is acquired as a function of depth while the vessel remains stationary. In constant-depth mode, the BOSS system is towed through the water continuously at a single depth. During towyo mode the BOSS is operated in a vertically undulating (ascent and descent) pattern to obtain data continuously at different depths while underway. This plume tracking exercise utilized the BOSS in primarily the towyo mode, although other modes were utilized in order to define the plume boundaries and concentrations.

FIGURE 2. OSV PETER W. ANDERSON

In addition to *in situ* measurements, discrete water samples were collected for laboratory analysis of water quality parameters (ammonia, total dissolved nitrogen, particulate nitrogen, total dissolved phosphorous, particulate phosphorous, and total suspended solids). Discrete samples were collected with the water pumping system integrated with the BOSS towfish/cable. This assembly consists of an instrument package and pump which is towed and powered by an electrical-mechanical cable (200 ft long) with a Teflon tube down the middle of the cable. This

sampling system will allow direct correspondence between discrete samples and *in situ* hydrographic data. Water is pumped to a sample collection station onboard the vessel by an internal gear pump located on the towed body. The pump lag-time was calculated while in the field. This lag-time was verified using an onboard flow through transmissometer. The transmissometer readings (inboard and outboard) are compared to ensure that the discrete sample is representative of the parcel of water measured by the *in situ* sensors. Sample processing (filtering, etc.) and preservation (freezing, etc.) was conducted onboard the OSV *Anderson.*

TABLE 3. INSTRUMENTS DEPLOYED FOR THE OFFSHORE PLUME SAMPLING.

Parameter	Lab	Units	Instrument	Reference
Conductivity	Battelle	Mmhos/cm	OS200 CTD	Ocean Sensors CTD manual (1999)
Temperature	Battelle	C	OS200 CTD	Ocean Sensors CTD manual (1999)
Pressure	Battelle	m	OS200 CTD	Ocean Sensors CTD manual (1999)
Beam transmittance	Battelle	m-1	Wetlabs C-Star 25cm Transmissometer	Wetlabs manual
Bottom depth	*Anderson*	m	Unknown	Unknown
Navigational position	*Anderson*	degrees	Northstar 942X	Northstar Manual
pH	Battelle	pH	Seabird SBE 18 sensor	Seabird SBE 18 manual
Salinity	Battelle	PSU	OS200 CTD	Fofonoff and Millard (1983)

Sample Handling, Shipping, and Custody Sample Storage Conditions. Initial processing of the discreet samples was conducted on the ship. Samples, filters, and filtrates were stored at the appropriate temperatures on board the ship. Each sample was assigned a unique ID and label by NavSam©, which also electronically stored the field and sensor data. Navsam© also generated chain of custody sheets to track all sample ID's. Samples were in the custody of the Battelle Second Scientist until they were shipped. Discreet samples were analyzed by Chesapeake Biological Laboratory (CBL). Sample storage conditions are presented in Table 4.

Table 4. Sample Processing, Packaging, and Shipping Requirements

Parameter	Sample Volume (mL) (Target)	Sample Containers	Shipboard Processing/ Preservation	Maximum Holding Time to Analysis	Packaging/ Shipping
Ammonia	10	20 to 50-mL glass digestion tube	Pass sample through a GF/F. Freeze filtrate until analysis.	28 days	Bubble Wrap tubes/ Ship on blue or wet ice
Particulate nitrogen	10 – 500 (500)	Whatman GF/F in foil	Pass sample through a GF/F. Freeze filter until analysis.	28 days	Place foil wrapped filters in Ziplocs/ Ship on blue or wet ice
Particulate phosphorus	25 – 500 (400)	Whatman GF/F in foil	Pass sample through a GF/F. Freeze filter until analysis.	28 days	Place foil wrapped filters in Ziplocs/ Ship on Blue or wet ice
Total dissolved phosphorus and nitrogen	10	20 to 50-mL glass digestion tube	Pass sample through a GF/F. Freeze filtrate until analysis.	28 days	Bubble Wrap tubes/ Ship on blue or wet ice
Total suspended solids	100 – 500 (300)	1-L dark bottle	Store water in 1-L bottle at 4˚C until delivery at CBL for filtration.	1 week	No specific packaging required/ Ship on blue ice

2.2. Pre-discharge Survey

The original survey plan for this monitoring effort included the collection of background measurements of the receiving waters immediately ahead of the discharging barge (Battelle 2003b). The first barge discharge was anticipated during the week of the July 7, 2003. The OSV *Anderson*, her crew, and the Battelle sampling team were in place to conduct monitoring efforts during this time. However, due to delays in the preparation of the barge dumping did not take place during this week (see further discussion in section 4.1). It was agreed to utilize this time-window to conduct a pre-discharge background survey of the receiving waters at the proposed dump site.

Background samples were collected along a transect which extended approximately 80nm from Northeast to Southwest through the permit area. The transect began approximately 90nm due west of Tampa Bay at the 100m depth contour interval. The location for this transect was based on the anticipated barge dumping route. Figure 3 shows the location of the transect and background stations during the pre-discharge survey. At three stations along this transect the vessel stopped, a vertical cast was conducted, and discrete water samples were collected at the pycnocline and at the surface. Samples were collected for all of the water quality parameters described above.

A scientific party from the Florida Department of Environmental Protection (FL DEP) was also aboard the OSV *Anderson* during this survey. This group conducted a concurrent pre-discharge survey independent of the EPA/Battelle survey. The FL DEP survey was conducted along the same trackline as the survey described in this report. At several stations measurements and

samples were collected by both parties. At all FL DEP stations, Battelle conducted a vertical cast with the *in situ* instruments. However, discrete nutrient samples were not collected at all of these stations.

2.3. Plume Tracking Survey

The actual plume tracking survey was conducted during the week of August 11, 2003. This survey captured the seventh dumping event. The OSV *Anderson* was docked at Port Manatee, FL at the berth adjacent to the loading berth of the Barge *New York* which carries the Piney Point wastewater. This location allowed direct communications between EPA, Battelle, and the Captain of the Tugboat *Cavalier*, who was responsible for dumping operations.

2.3.1. Background

Prior to departure from the dock, discussions were held with the captain of the Tugboat *Cavalier* to determine the dumping schedule and planned trackline. Figure 3 shows the EPA permitted dispersal zone, Florida DEP's planned dispersal zone (a subset of the permitted area), and the planned vessel tracklines for the discharge. Once the planned dumping schedule and location was confirmed, the *Anderson* transited to a point along the discharge route approximately 130 nm offshore and 15 nm from the planned start point for the discharge. At this location background transects were conducted in towyo mode perpendicular to the planned discharge route. As the EPA vessel crossed the planned discharge route two sets of discrete water samples were collected to determine background concentrations prior to dumping.

2.3.2. Plume Tracking

Once the background transects and sample collections were completed, the vessel stood by to the south of the discharge route to await the arrival of the barge. During this time radio communication was maintained with the captain of the *Cavalier* to monitor the progress of the dumping operations.

The first trackline was conducted immediately after the dumping vessel passed (see survey chronology, section 2.4.2). This trackline was designed to capture the initial discharge concentration in the receiving waters. Several *in situ* measurements were monitored in an attempt to identify the location of the plume, including beam attenuation, salinity, and pH. As the survey vessel passed behind the barge, a drogue was deployed. The drogue was intended to provide a visual cue for survey operations.

Continuous tracklines were planned to monitor the dispersal of the wastewater plume. However, the plume was not detected by the *in situ* sensors so the sampling scheme was modified in the field. Rather than conducting repeated towyo tracklines across the dispersal route, the drogue was tracked and discrete samples were collected at the drogue location.

2.4. *Survey Chronology*

All times are recorded as Eastern (Daylight Savings) Time.

2.4.1. Pre-discharge Survey

Monday July 7, 2003

0700 – 1530	Battelle personnel travel to USCG station, St. Petersburg, FL.
1530 – 1800	Begin mobilization aboard OSV *Peter W. Anderson.*
–	**Barge status:** Undergoing cleaning and inspections. First fill planned as slow fill (~3 days). Earliest departure July 11, 2003.

Tuesday July 8, 2003

0730 – 1800	Continue mobilization.
1000 – 1100	Survey planning meeting: Battelle, EPA, FL DEP, *Anderson* Captain. Create pre-discharge plan.
–	**Barge status:** Continued cleaning and inspections. Earliest departure July 12, 2003.

Wednesday July 9, 2003

0730	Continue mobilization.
1000 – 1030	Survey status meeting: Battelle, EPA, FL DEP.
1200	Depart dock for discharge area.
1400	Mobilization complete.
–	**Barge status:** Barge cleaning failed inspections, additional cleaning required. Earliest departure July 14, 2003.

Thursday July 10, 2003

0630	On station VC1 (FL DEP #A-1). Test equipment.
0730	Station VC1 vertical cast conducted, discrete samples collected.
0848	On station VC2 (FL DEP #AStart). Vertical cast conducted, no discrete samples collected.
1005	On station VC3 (FL DEP #A1). Vertical cast conducted, no discrete samples collected.
1120	On station VC4 (FL DEP #A2). Vertical cast conducted, discrete samples collected.
1245	On station VC5 (FL DEP #A3). Vertical cast conducted, no discrete samples collected.
1500	On station VC6 (FL DEP #A4). Vertical cast conducted, no discrete samples collected.
1725	On station VC7 (FL DEP #A5). Vertical cast conducted, discrete samples collected.
–	**Barge status:** No update. Still anticipating earliest departure July 14, 2003.

Friday July 11, 2003

0630	On station VC8 (FL DEP #B1). Vertical cast conducted, no discrete samples collected for chemical analysis. Water collected from 5 depths to use as a check against *in situ* salinity readings.
0913	On station VC9 (FL DEP #B2). Vertical cast conducted, no discrete samples collected for chemical analysis. Water collected from 5 depths to use as a check against *in situ* salinity readings.
1125	On station VC10 (FL DEP #B3). Vertical cast conducted, no discrete samples collected for chemical analysis. Water collected from 5 depths to use as a check against *in situ* salinity readings.
1245	On station VC11 (FL DEP #B4). Vertical cast conducted, no discrete samples collected for chemical analysis. Water collected from 5 depths to use as a check against *in situ* salinity readings.
1410	On station VC12 (FL DEP #B5). Vertical cast conducted, no discrete samples collected.
1529	On station VC13 (FL DEP #BEnd). Vertical cast conducted, no discrete samples collected.
1655	On station VC14 (FL DEP #B-1). Vertical cast conducted, no discrete samples collected.
1730	Depart discharge area for St. Petersburg.
–	**Barge status:** No update. Still anticipating earliest departure July 14, 2003.

Saturday, July 12, 2003

1400	Arrive at USCG Station St. Petersburg, FL.
–	**Barge status:** No update. Still anticipating earliest departure July 14, 2003.

Sunday July 13, 2003

–	**Barge status:** No update. Still anticipating earliest departure July 14, 2003. On standby.

Monday July 14, 2003

–	**Barge status:** Cleaning still required for barge. Barge not yet ready to transit to filling location at Port Manatee. Earliest anticipated departure for barge July 17, 2003.
1000	Planning meeting with Battelle and EPA. Decision made to demobilize until firm schedule in place.
1100 – 1700	Demobilize. Battelle personnel departs Florida.

2.4.2. Plume Tracking Survey

Monday August 11, 2003

0700 – 1600	Battelle personnel travel to Port Manatee, FL.
1600 – 1900	Meet with FMT stevedore service at Port Manatee to receive shipped equipment and arrange for loading of OSV *Peter W. Anderson.*
–	**Barge status:** Returning from dumping event #6. Expected to arrive this evening. Expected to begin refilling immediately and depart on August 13, 2003.

Tuesday August 12, 2003

0800 – 1800	Begin mobilization aboard OSV *Peter W. Anderson.*
1200	Survey planning meeting with Battelle, EPA, Captain of *Anderson,* and Captain of *Cavalier* (Tug towing barge).
1630	Depart Port Manatee for survey area.
–	**Barge status:** Barge filling underway. Anticipated departure at 0500, August 13.

Wednesday August 13, 2003

0945	Arrive at survey area.
1300	Complete equipment mobilization, set up for survey.
1722	Collect blank filtrations.
1730	Radio contact with *Cavalier.* Discuss discharge schedule. Decide to relocate *Anderson* and survey operations ~10 nm further west along the discharge route to ensure that dumping is at full rate.
2000	Check equipment operation. Perform flow rate measurements and calculations.
2044	Perform first background transect BK_A. Collect discrete samples.
2125	Perform second background transect BK_B. Collect discrete samples.
2153	Receive communication from *Cavalier* that barge discharge is at full rate, ~4,000 L/minute.
2228	Barge passes *Anderson*. Begin towyo transect across discharge line.
2234	Cross discharge line. Deploy drogue. Plume not detected.
2243	End S-N transect. *Anderson* turns back towards discharge line.
2251	Cross discharge line again. Plume not detected. Collect discrete samples at 6.3m. Station T0_A.
2258	End N-S transect. *Anderson* turns back towards discharge line.
2305	Cross discharge line again. Plume not detected. Drogue is moving quickly away from discharge line.
2336	Sample station T.5A at drogue location, at ~4.2m. Approximately 725m Southeast of Station T0_A.

Thursday August 14, 2003

0021	Sample station T1_A at drogue location, at ~4m. Approximately 1500m Southeast of Station T0_A.
0054	Sample station T2_A at drogue location, at ~4m. Approximately 1700m Southeast of Station T0_A. Complete sampling.
0109	Recover drogue. Depart survey area for Port Manatee. Seas building over night from Tropical Storm Erika.
2030	Arrive Port Manatee.

Friday August 15, 2003

0700 – 1700 Demobilize. Battelle personnel departs Florida.

3. Survey Results and Discussion

This report describes the results of *in situ* measurements and discrete samples collected during the two surveys. Under the conditions of the EPA permit, the Piney Point dumping must occur at least 40 nautical miles from shore in waters at least 40 meters deep. In an effort to further reduce the impact of the discharge, the Florida Department of Environmental Protection has selected a sub-region of the permitted area to conduct all discharges. This area moves the commencement of the discharge to 100 nm at ocean depths greater than 200m. Figure 3 shows the EPA permitted area, the FL DEP dispersion area, and the planned tracklines for the barge.

3.1. Field Activities and Observations

3.1.1. Pre-discharge Survey

The pre-discharge survey was conducted to determine ambient conditions in the receiving waters of the permitted area prior to the onset of dumping operations. During this survey vertical casts were conducted at a series of stations in the vicinity of the proposed dumping area. During these vertical casts continuous hydrographic data was collected in order to define the physical structure of the upper water column (<45m). At three stations discrete samples were collected at the pycnocline and at the surface for analysis of the chemical parameters defined in Section 2. These 14 stations coincided with sampling conducted by the FL DEP during the same survey. Figure 4 shows the tracklines and sampling stations during the pre-discharge survey.

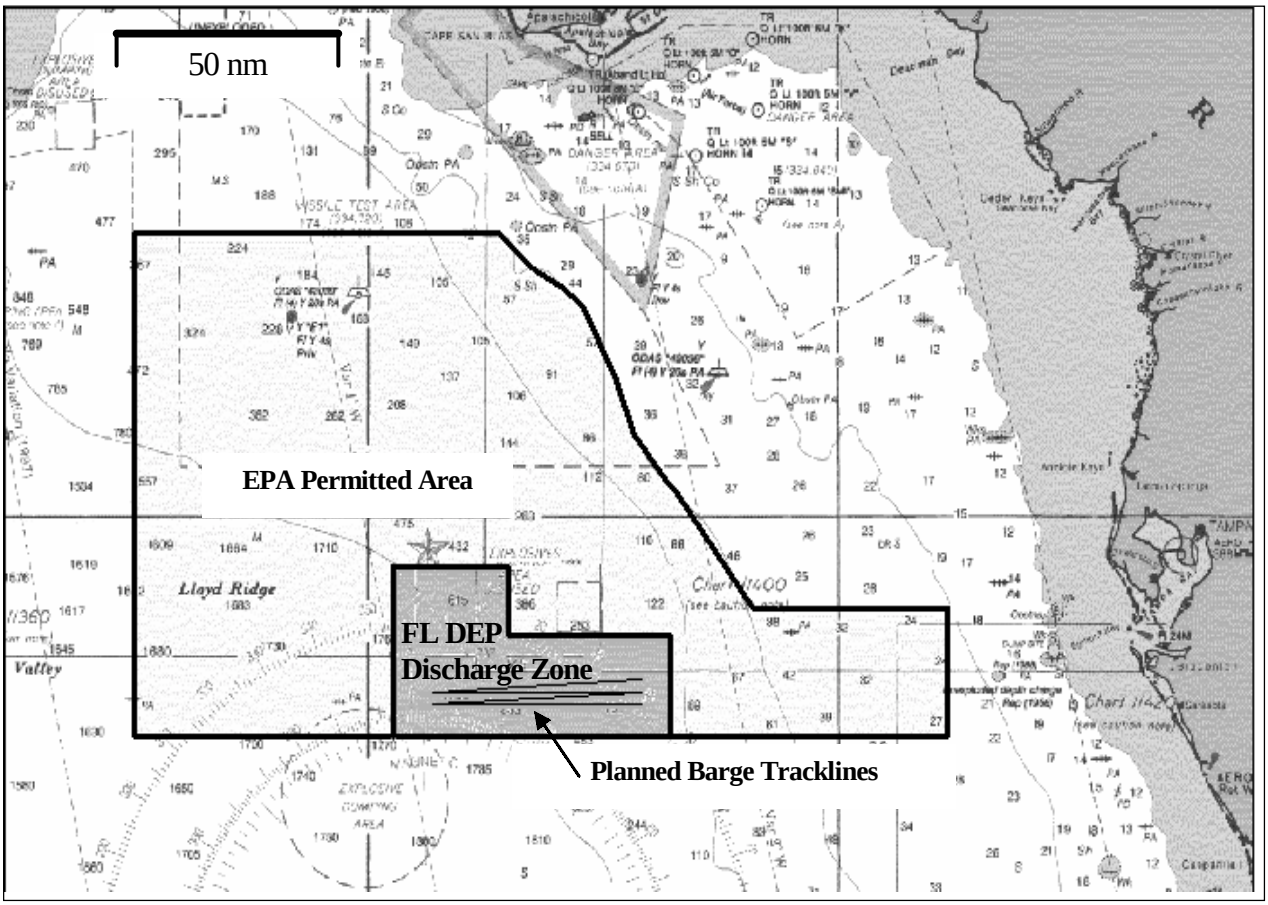

FIGURE 3. MAP OF EPA PERMITTED AREA, FL DEP DISCHARGE ZONE, AND PLANNED BARGE TRACKLINES.

Vertical casts at these stations were conducted to a maximum of 45m (the length of the towyo cable). Physical measurements during these casts showed weak stratification with the top of the pycnocline at approximately 25m at most stations. Surface water temperatures were ~29-30˚C, declining to ~22-24˚C at the bottom of the casts. Surface salinities were generally ~33-35 PSU. However, at station VC6 surface salinity was only 31 PSU. This appeared to be due to a Mississippi river influence towards the western end of the survey area. Salinities in the deeper waters were ~36-37 PSU throughout the area (see section 4.2 for a discussion of problems with salinity measurements during this survey). As expected, pH was stable at ~8.1 throughout the water column at all stations. Beam attenuation was low and generally stable throughout the entire area. A few spikes were seen in the beam attenuation readings that were likely due to turbulence or individual particles in the water column. There was a fair amount of floating macroalgae and *trichodesmium* mats which may have occasionally crossed the transmissometer beam. Typical beam attenuation values were ~0.6 1/m. Table 5 lists the minimum, maximum, and average values for all *in-situ* parameters measured at these stations.

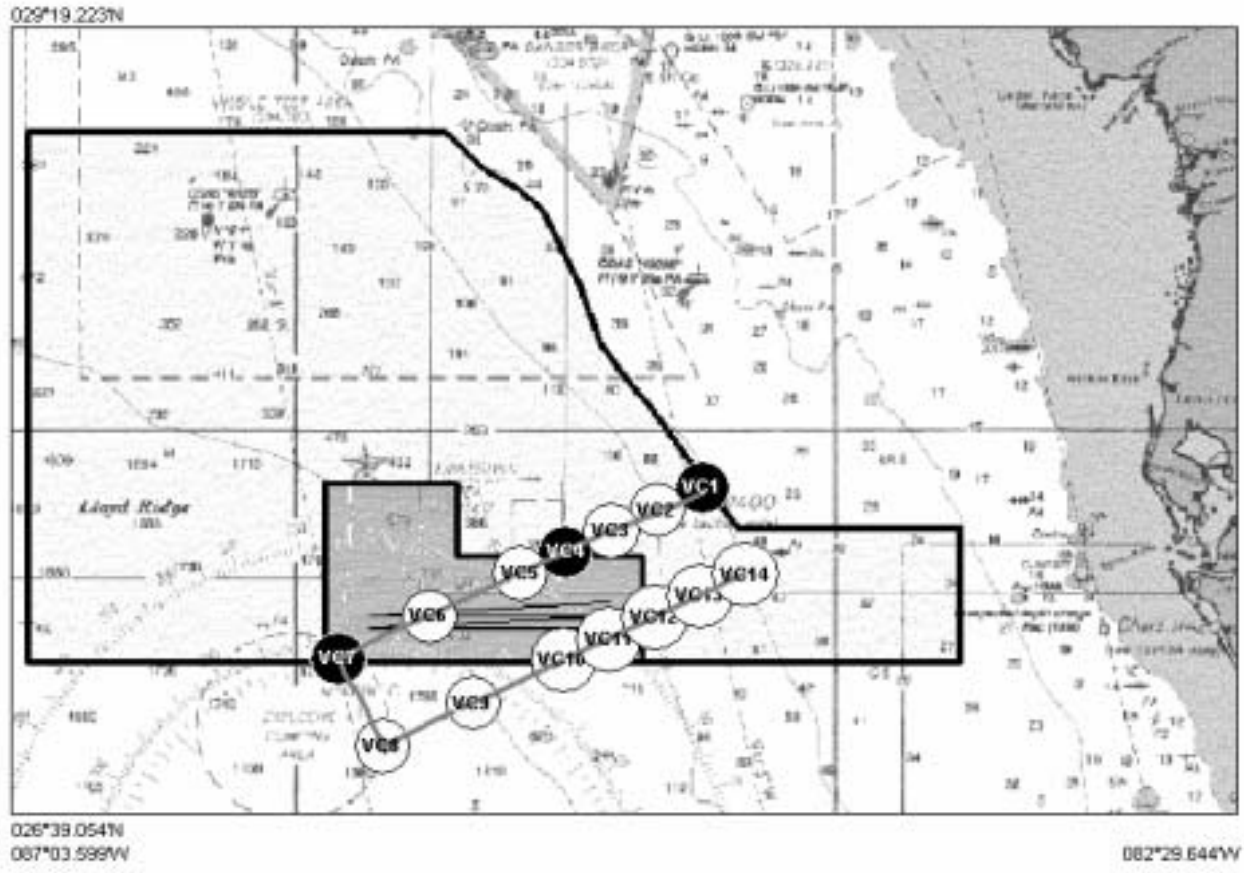

FIGURE 4. TRACKLINES AND SAMPLING STATIONS DURING THE PRE-DISCHARGE SURVEY. FILLED IN STATIONS REPRESENT THE LOCATION OF DISCRETE SAMPLES

TABLE 5. DATA SUMMARY TABLE FOR PRE-DISCHARGE SURVEY.

July	Value				Minimum		Maximum	
Parameter	Minimum	Average	Maximum	Units	Station	Depth	Station	Depth
Salinity[1]	31	35	37	PSU	VC6	2.2	VC2	39.7
Temperature	21.4	27.4	30.3	˚C	VC1	44.7	VC13	0.8
Depth	0.0	23.6	45.4	m	VC11	0.0	VC11	45.4
Sigma-T	20.8	24.3	27.9		VC6	1.5	VC1	44.1
pH	8.0	8.1	8.2		VC1	23.4	VC5	1.1
Light Attenuation	0.5	0.6	1.9	1/m	VC5	29.0	VC11	0.6

[1] Approximate values, see section 4.2 for discussion of problems with July salinity data.

3.1.2. Plume Tracking Survey

The first discharge under the EPA permit was conducted on July 20, 2003. Subsequent discharges were conducted on July 24, 28, August 1, 5, and 10, 2003. This section describes the EPA monitoring activities conducted during the seventh discharge event, conducted on August 13 and 14, 2003. The plume tracking survey included background sampling prior to the onset of the discharge, and sampling in the wake of the discharge. Figure 5 shows the sampling area.

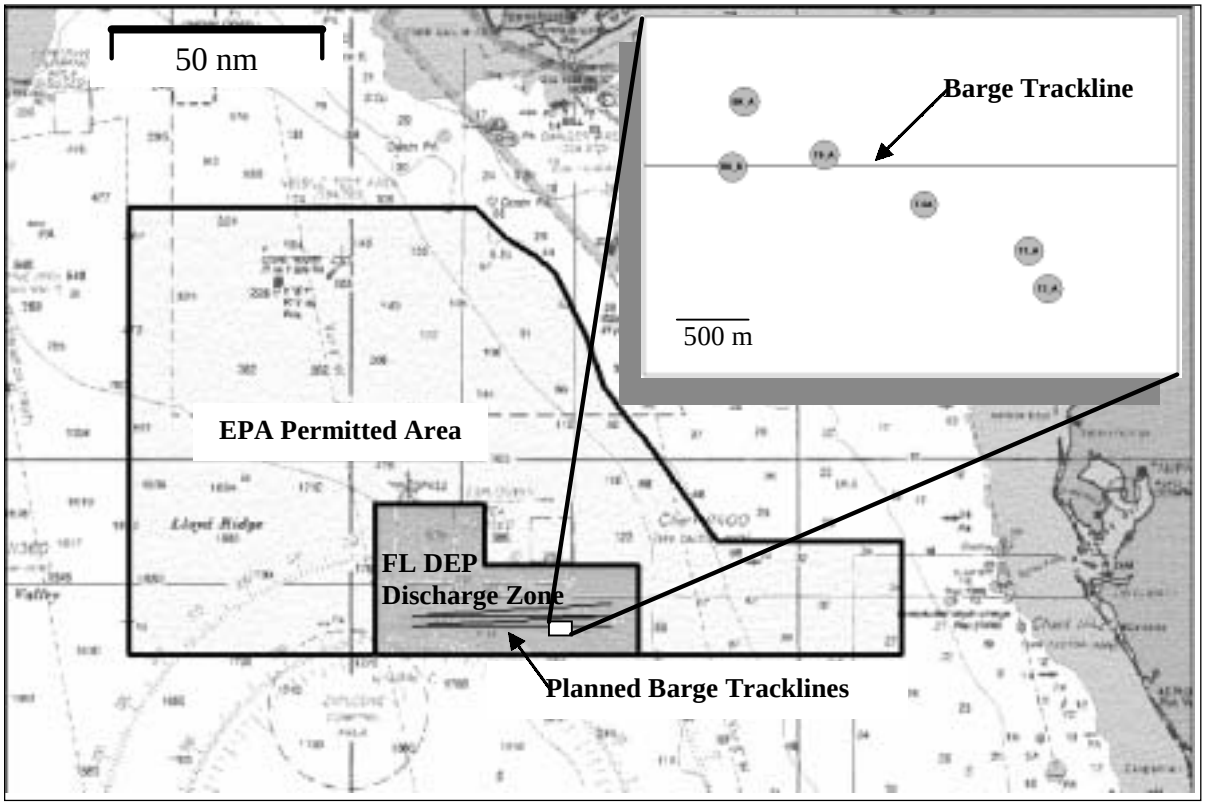

FIGURE 5. BACKGROUND AND PLUME-TRACKING SAMPLE STATIONS (INSET)

3.1.2.1. Background

A location approximately 15nm into the discharge track was selected as the area to be surveyed. This location was selected so that the barge would be at a stable speed and discharge rate by the time it passed the survey vessel. Approximately 1 hour before the barge reached the area a series of towyo transects were conducted across the barge route. During these transects discrete water samples were collected at two locations. Figure 6 shows the background transects and discrete sampling locations relative to the barge trackline.

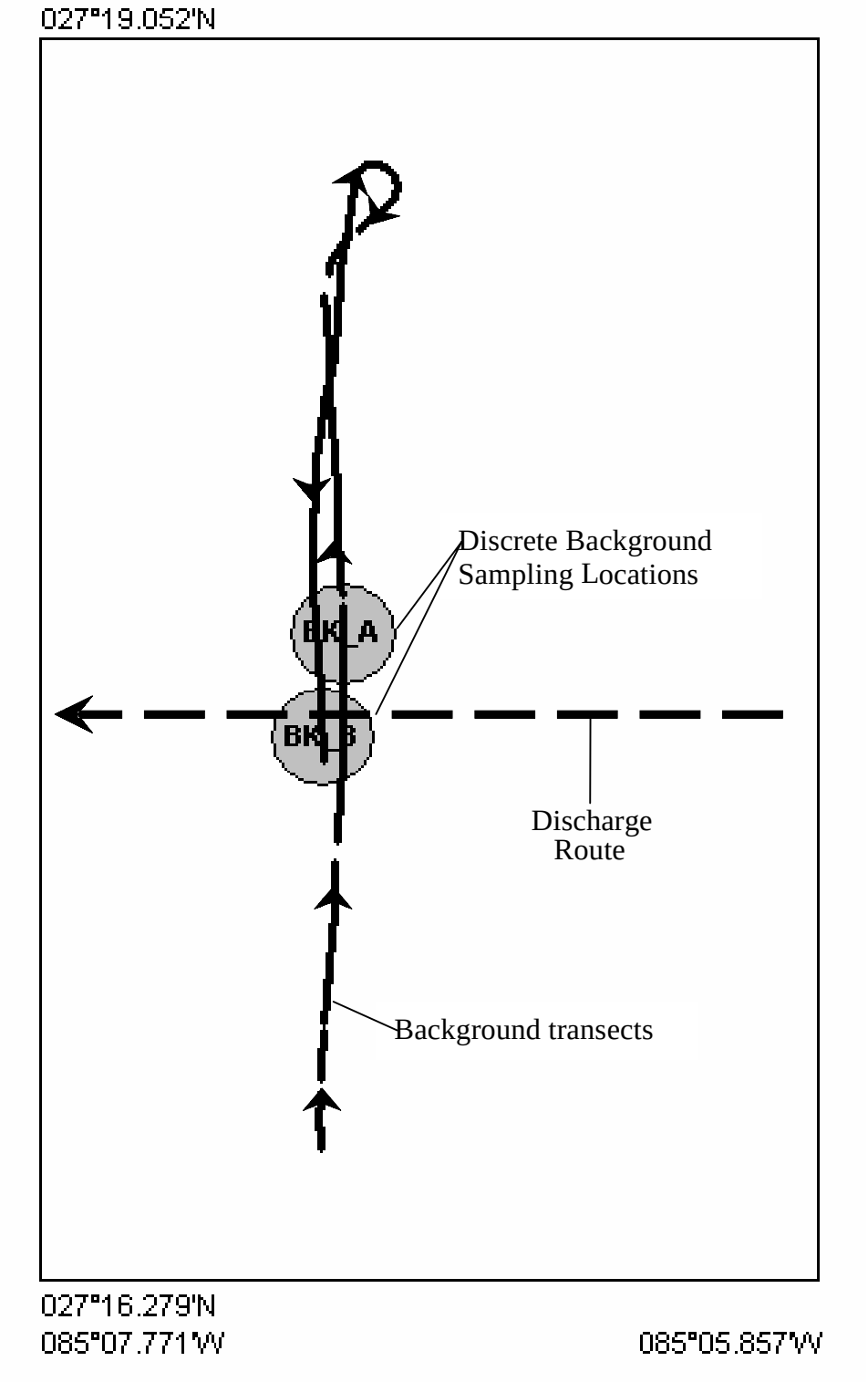

FIGURE 6. BACKGROUND TRANSECTS AND SAMPLE LOCATIONS

During these background transects all data were collected with the sensor suite in towyo mode. As a result a maximum depth of 22m was reached, as compared to 45m for the vertical casts conducted during the pre-discharge survey. The physical structure of the water column had changed somewhat from the July survey. A more distinct halocline was present throughout the area. Surface salinities were ~32.8 PSU and increased sharply to ~36 PSU between 7 and 10m. The decreased surface salinities may have been the product of heavy rainfall in the days leading up to the survey. The national weather service reported that August 2003 was one of the top 5 wettest Augusts on record, with Manatee County receiving nearly 18 inches of rain (www.srh.noaa.gov/climate/monthly/F6TPA_0803.htm). In the week leading up to the survey the area received over 5.5 inches of rain. Surface water temperatures were ~30˚C, and began to decline slowly below 10m. Because towyos reached only 22m the deeper thermocline seen in July may have been missed. A stable pH reading of 8.3 was consistent with the July average pH of 8.1. Beam attenuation values were again low and a generally stable with a mean of 0.6 1/m. Occasional spikes as high as 1.5 1/m were seen, but these did not appear to be associated with the plume. Instead, they seemed similar to the spikes observed in July which were associated with individual particles.

3.1.2.2. Plume Tracking

Following the collection of background samples the *Anderson* moved to a location ~1000m south of the discharge route to await the arrival of the barge. At 22:28 the barge passed the *Anderson*. At this point the barge was traveling at just over 5 knots and discharging at rate of ~3535 gallons per minute (GPM) (FL DEP, September 5, 2003). As the barge passed, the *Anderson* initiated the first plume-tracking transect by heading north towards the discharge line. The sensors were operated in towyo mode in order to detect any physical signs of the plume between 20m and the surface. At 22:34 the *Anderson* crossed the discharge line, intersecting the barge wake approximately 6 minutes and 1000m behind the barge. A tracking drogue was deployed off the stern of the *Anderson* as the discharge line was crossed. No physical signs of the wastewater plume had been observed by this point so the trackline was continued towards the north in attempt to identify it. The trackline was continued in towyo mode for approximately 1000m to the north of the discharge line, still with no identifiable signature of the plume.

The vessel was turned back to the south to conduct a second trackline through the discharge area. Although there continued to be no clear sign of the plume, discrete water samples were collected at the discharge line at a depth of 6 meters (station = T0_A). The north-south trackline was continued back to the starting point ~1000m south of the discharge line. The vessel was then turned back to the north for a final transect through the discharge area. Again, no plume signature was observed in the physical data. Figure 7 shows the initial plume tracking tracklines.

During the towyo transects no evidence of the wastewater plume was seen in the physical data obtained from the *in situ* sensors. Therefore, it was decided to use the tracking drogue as the sampling location for the remainder of the survey. Following deployment in the plume wake the drogue traveled fairly fast in a southeasterly direction. In the first hour after deployment the drogue had drifted approximately 725m to the SW. This was the location for the second discrete sampling event. A vertical cast was conducted at this location (station = T.5A) in an attempt to identify any plume signature. Although no physical signature was identified discrete samples

were collected from 4m. The vessel then drifted with the drogue and collected samples at 2 additional stations: 1) Station T1_A, 1500m SW of deployment, 3m depth and 2) Station T2_A, 1700m SW of deployment, 4m depth. Sample collections were discontinued after station T2_A. Figure 8 shows the location of each plume tracking station.

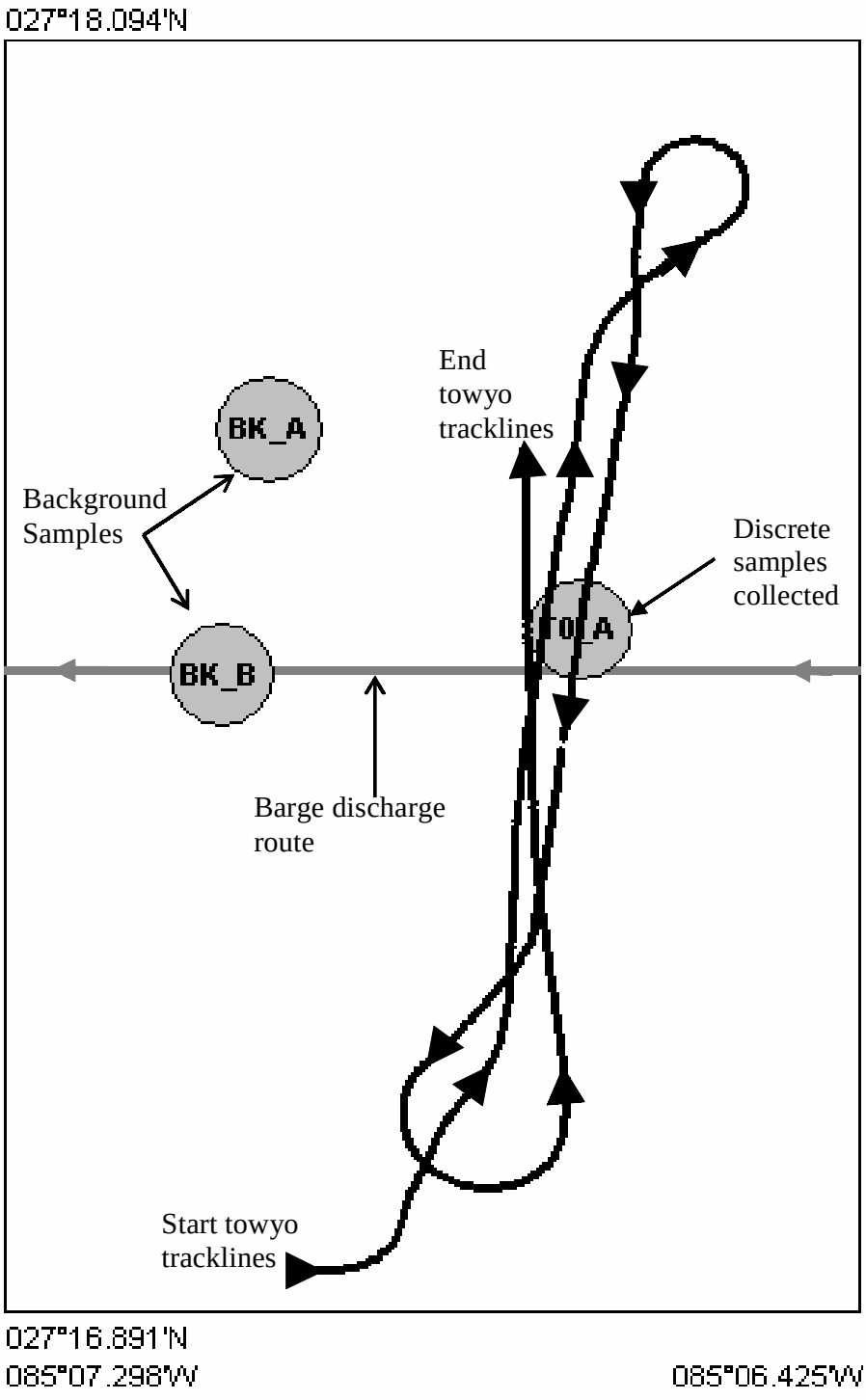

Figure 6. Initial Plume Tracking Towyo Tracklines

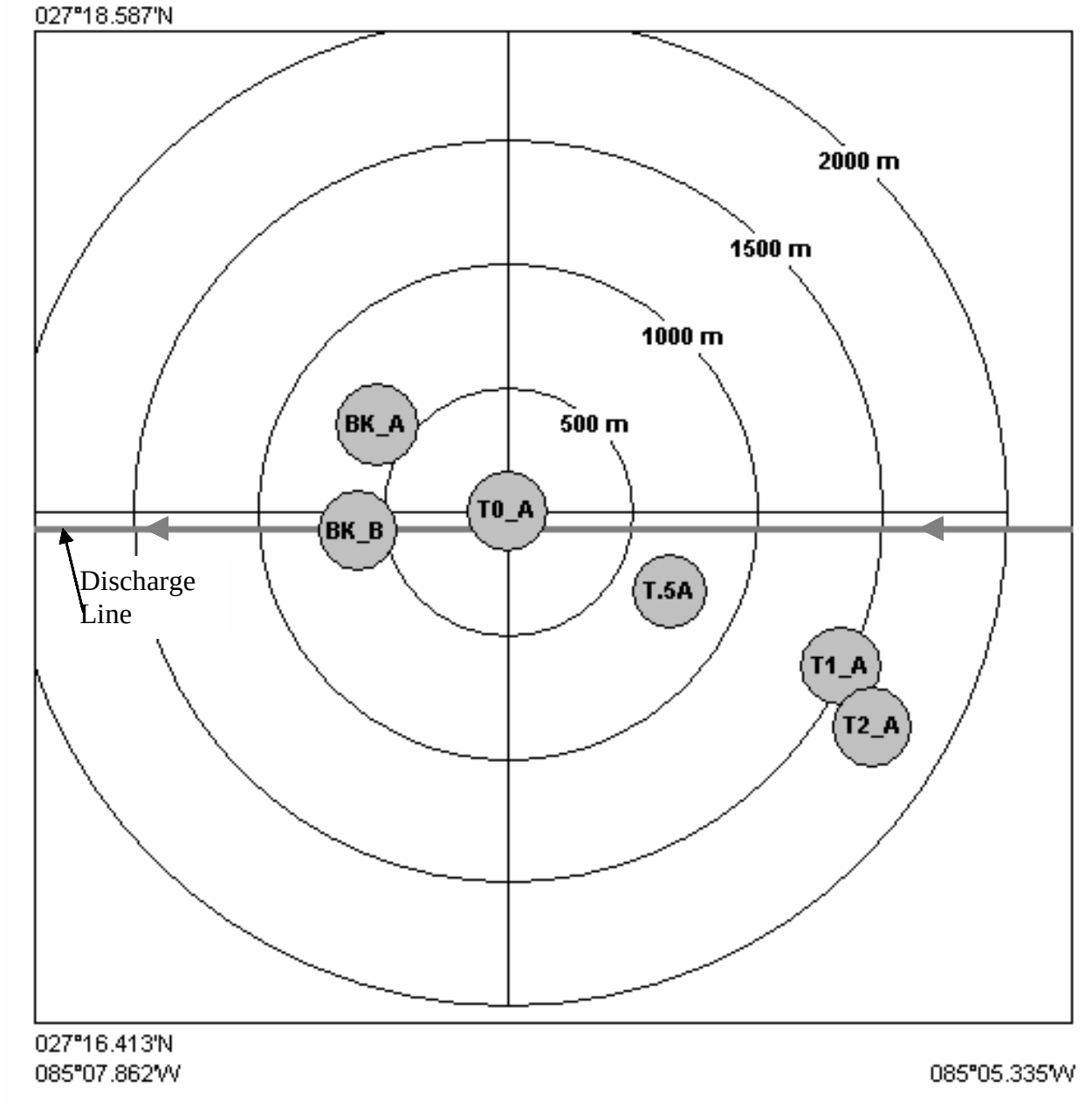

FIGURE 7. PLUME TRACKING DISCRETE SAMPLE LOCATIONS

3.2. Discrete Sample Results

Table 7 provides analytical results for all discrete samples collected during each portion of the study. Results are average of replicate samples at each station and depth. Nutrient concentrations and total suspended solids were low throughout the area during all sampling events. Ammonia was the only parameter that showed an increase from pre-discharge levels. The increase in NH^4 concentration was seen in the August background samples as well as in the samples collected behind the barge.

Table 7. Analytical Results for all Discrete Samples.

	Statio	Dept (m)	TDP (ìg at	TDN (ìg at	NH4 (ìg at	PN (ìg at	PC (ìg at	TSS (ìg/l)	PP (ug
July	VC1	24.4	0.24	13.68	0.65	1.01	5.99	666.67	0.06
Pre-	VC1	0.92	0.19	21.45	0.70	1.38	7.54	1040.0	0.06
Discharg	VC4	26.2	0.16	14.24	0.50	0.79	4.80	353.33	0.05
Samples	VC4	1.25	0.14	17.04	0.50	1.20	6.60	260.00	0.05
	VC7	28.5	0.17	29.24	0.90	0.83	5.35	240.00	0.05
	VC7	1.32	0.19	19.72	0.70	1.89	15.80	600.00	0.08
August	BK_A	4.87	0.16	19.24	1.55	1.14	8.83	2250.0	0.05
Backgrou	BK_B	7.14	0.17	15.95	1.95	1.16	9.09	600.00	0.05
August	T0_A	6.38	0.16	15.94	2.00	1.05	7.97	933.33	0.05
Plume	T.5A	4.46	0.22	13.31	1.55	1.24	9.38	883.33	0.05
Tracking	T1_A	3.34	0.17	10.89	1.65	0.97	7.16	800.00	0.04
	T2_A	4.53	0.14	12.43	3.75	1.05	7.60	416.67	0.04

4. Problems Experienced, Actions Taken, and Recommendations

4.1. Schedule

The original planning for the plume tracking survey was designed to assess discharges from the first dumping of the Piney Point waste. Delays with the barge preparation and cleaning lead to a postponement of the plume tracking survey until the seventh discharge event conducted in mid August 2003. This deviation resulted in an overall improvement in the sampling design by allowing time for a prep-discharge survey to establish conditions in the dumping zone prior to actual discharge.

4.2 Technical

During the pre-discharge survey there was a persistent electrical short in the conductivity probe on the CTD. Despite repeated attempts to isolate and repair the problem, no remedy was identified. This problem resulted in conductivity readings that were noisy and lower than expected. Because salinity is calculated from the conductivity readings salinity values were also affected. A hand-

held refractometer was used during the survey to measure approximate salinity values at multiple depths during the vertical profiles. A new CTD was used on the August survey and clean conductivity data was collected. Following the August survey the conductivity data from the two surveys were compared to develop a post-processing correction for the July conductivity/salinity data. By using readings from subpycnocline depths where salinity is expected to be fairly stable, an equation was developed to fit the July data to the August data. This equation was used to post-process and correct the July salinity data. The corrected values were compared to the refractometer data to assess the approximate fit. Although this comparison is very rough, there was good agreement. In addition, the corrected salinity values were compared to surface salinity data collected during the concurrent survey conducted aboard the *Anderson* (Hu and Muller-Karger, 2003). There was good agreement between these data sets, although this was also a very rough comparison.

The corrections applied to the July conductivity/salinity data provide an approximate measure of these parameters and are useful in determining the physical structure of the water column. Because of the inherent uncertainty in this post-processing the July conductivity/salinity data must be considered suspect and used cautiously.

5. References

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